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MISCELLANEOUS ELECTRICITY USE IN THE U.S. RESIDENTIAL SECTOR

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EXECUTIVE SUMMARY

In this study, we developed a detailed bottom-up model of the miscellaneous electricity end use. Using shipment data and a consistent stock accounting framework, we estimate the energy use of 97 product types of varying importance over a 34 year period (1976-2010). Our study has two components: a historical analysis of miscellaneous electricity use (1976-1995), and an end use forecast (1996-2010). Our historical analysis is based on shipment data for the period 1976 through 1995. For the majority of product types, our miscellaneous electricity forecast is based on either industry projections of future shipments or ARIMA models. By disaggregating the miscellaneous end use into more than ninety product types, our study provides the product-specific information that is necessary for directing future research, policy, and public information efforts.

The main findings from our analysis are as follows:

- Our study reveals issues associated with the current definition of the miscellaneous end use. In order to compare our results to estimates published in AEO97, our definition is consistent with EIA's miscellaneous end use break-down. We found that some product types currently defined as "miscellaneous" belong in conventional end use categories. For example, our miscellaneous definition includes microwave ovens, clothes washer and dishwasher motors, and evaporative coolers. We also found that the miscellaneous end use also includes energy use from new product types that have not been incorporated into EIA's conventional end use categories. The halogen torchiere lamp is an example of a new, but not "miscellaneous", product type that is included in the study due to definition issues.

- During the period 1976 to 1995, miscellaneous electricity consumption increased at an annual rate of 4.6%. In 1995, miscellaneous electricity consumption totaled 235 TWh, accounting for approximately one quarter of total residential electricity use. From 1996 through 2010, we project that miscellaneous electricity consumption will increase 115 TWh, accounting for over 90% of forecasted residential electricity growth.

- Our 1995 estimate for miscellaneous electricity consumption as well as our forecasted miscellaneous growth from 1996 to 2010 are lower than estimates published in AEO97. AEO97 estimates 1995 miscellaneous electricity at 337 TWh, compared to our estimate of 235 TWh. AEO97's forecasted growth rate from 1996 to 2010, 3.8%, is higher than our projected growth rate of 2.7%.

- Miscellaneous product types can be binned into four broad categories**:** consumer electronics, electric resistance heaters, lighting, and small motors. We found that from 1976 to 1995, growth in consumer electronics product types (64 TWh) accounted for nearly half of miscellaneous electricity growth over this period. From 1996 to 2010, we project that consumer electronics and halogen torchiere lamps will together account for 70% of forecasted miscellaneous growth.

- We included 97 individual product types in our study and found that only ten product types were responsible for over half of current miscellaneous consumption and forecasted miscellaneous growth. The following ten product types (listed in priority order based on absolute electricity consumption-the first product type listed having the highest energy consumption) were responsible for 53% of miscellaneous consumption in 1995:

Color television
Furnace fan
Waterbed heater
Torchiere lamp
Microwave oven
Auto Drip Coffee Maker
Clothes washer Motor
Dishwasher Motor
Ceiling Fan
Video cassette recorder

The following ten product types (listed in priority order based on absolute projected growth-the first product type listed having the highest forecasted energy growth) are projected to account for 60% of forecasted miscellaneous growth from 1996 to 2010:

Torchiere lamp
Color television
Dehumidifier
Security system
Compact audio system
Microwave oven
Projection television
Satellite System
Pool pump
Home computer

- Our results show that 20% of residential miscellaneous electricity (43 TWh) is consumed while in standby mode. Nearly all standby consumption is attributed to consumer electronic product types. In 1995, nearly half of all consumer electronics energy was consumed while in standby mode. In terms of absolute consumption, the largest leakers include compact audio systems and component audio systems, televisions, cable boxes, and VCRs.

- Reducing the standby power to one watt per unit for all product types with a standby mode has the potential to reduce U.S. standby consumption to 22 TWh, nearly a 50% reduction from current levels. By focusing only on standby losses, U.S. miscellaneous electricity consumption would be reduced by 21 TWh, saving roughly $1-2 billion annually. Other important efficiency opportunities include replacing halogen torchiere lamps with alternative CFL models, and improving the efficiency of fans for fuel-fired furnaces.

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INTRODUCTION[1]

The Annual Energy Outlook 1997 (AEO97), published by the U.S. Energy Information Administration (EIA), contains a forecast by sector and fuel type. Estimates from AEO97 show that miscellaneous electricity is one of the largest and fastest growing residential energy end uses. Miscellaneous electricity is a complex end use that includes many household appliances. Identifying the largest miscellaneous product types (in terms of current consumption and forecasted growth) is necessary for directing future research and policy efforts (Koomey, 1996a). The AEO does not provide this type of detailed product-specific information. Given the policy importance of miscellaneous electricity and the historic lack of information, we developed a detailed bottom-up model to provide end use insight. This model is used to decompose the miscellaneous end use, to develop an independent forecast, and to highlight policy priorities.

Study Overview

The purpose of this study is to build a "bottom-up" end use model, and to compare our shipment-based trends with the aggregate energy use forecast presented in AEO97. Using trends in shipment data as well as industry estimates of future growth, our model provides a useful comparison and cross-check of AEO97 projections (U.S. DOE, 1996).

This study provides basic end use information and estimates of consumption and growth that may guide future, more detailed efforts. In this study, we estimate the magnitude of the miscellaneous end use, determine historic and predict future growth, and identify the largest product types within the miscellaneous end use.

DEFINING THE MISCELLANEOUS END USE

The definition used in this study is consistent with EIA's miscellaneous electricity end use definition in AEO97. Definitions are necessarily the same so that our results can be compared to the estimates published in AEO97.[2] Several product types included in our study belong in conventional end use categories. For example, microwave ovens are technically a "cooking" end use, but EIA currently treats them as a miscellaneous end use. Other examples of potentially inappropriately classified miscellaneous product types include

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[1]This report contains numerous figures and tables referred to throughout the text. To increase the readability of the report, the graphs and tables are located in appendices. Appendix A contains all figures, and all tables are located in Appendix B.

[2]The AEO "other" or miscellaneous end use also includes a State Energy Data System (SEDS) adjustment. The SEDS is a state by state energy accounting system that uses utility data to estimate aggregate energy use. Because SEDS is a more reliable estimate, the AEO forecast is adjusted so that its total electricity estimate equals the SEDS estimate. This adjustment appears in the miscellaneous, "other" end use. The SEDS adjustment includes miscellaneous product types not included in the conventional end use categories. It would also include energy unaccounted for if (for example) actual lighting, water heating or space conditioning consumption was higher than EIA's estimates calculated from RECS. It is classified as "other" not necessarily because it is miscellaneous energy, but because it is unexplainable within the methodology framework. Our model includes 90 miscellaneous product types. We do not have a SEDS adjustment which means that our model does not capture energy use for products not specifically included in the study (bread makers for example). We believe that we have captured the majority of miscellaneous energy use (only 10 products account for most of our miscellaneous electricity); however, the SEDS adjustment is one area where our definition does diverge.

furnace fans, ceiling fans, dehumidifiers and evaporative coolers (intuitively, these are thought of as space conditioning end uses). The miscellaneous definition used in this study reflects EIA's accounting practices in AEO97.

Our miscellaneous end use definition also includes new product types were not (as of AEO97) included in EIA's conventional end use categories. The AEO97 forecast for miscellaneous energy use is based on extrapolation of recent trends embodied in the U.S. DOE's market surveys. EIA's Residential Energy Consumption Survey (RECS) did not include a halogen torchiere question in the lighting component of the survey. Without asking a separate question, results of the lighting survey cannot capture halogen torchiere lamps (since the wattage and usage are substantially different than that of conventional incandescent lamps). As a result, the energy use from torchieres in AEO97 is included in EIA's miscellaneous end use as opposed to the lighting end use[3]. For the purpose of comparison, torchieres are also included in our analysis.

We do not know the extent to which torchieres are displacing other lighting sources within the conventional lighting end use. There are two plausible scenarios. People may be substituting halogen torchiere lamps for conventional lamps on a one to one ratio. In this scenario, the amount of light remains the same, but the lighting source efficiency declines (the lumens/watt of torchieres is lower than that of conventional lamps). It is also possible that people are supplementing their lighting with torchieres. In this scenario, more light is provided, and it is provided with a comparatively less efficient source. In both scenarios, the energy use of lighting increases because of the efficiency of halogen torchiere lamps. The amount of increase is still unknown. Our study does not include this potential substitution effect or its energy implications within the lighting end use, but our estimates of total torchiere consumption are the first step to assessing its importance.

In the future, it may be appropriate for EIA to re-assign some currently defined miscellaneous product types to conventional end use categories. This potential restructuring of EIA's end use categories will reduce the amount of energy consumption attributed to "miscellaneous" uses. In part as a response to our analysis, EIA has begun to address this issue in AEO98 by creating separate forecasts for clothes washer and dishwasher motors, halogen torchieres (under the lighting end-use), color televisions, personal computers, and furnace fans (previously in the "other" category) (US DOE, 1997). EIA also broke up the remaining unidentified miscellaneous energy use into electronics, heating coils, and motors, just as we aggregate our results into these categories later in the report. One result of re-thinking the miscellaneous end use may be newly defined or expanded end use categories that better capture how energy is used in the home. Important miscellaneous product types identified in this study are still key energy users independent of their end use classification.

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[3]The AEO97 forecast is based on trends calculated from RECS data. The "other" end use defined in RECS includes miscellaneous appliances as well as all other energy not accounted for in the lighting, space conditioning, refrigeration and water heating end uses by the conditional demand analysis. Because torchiere energy cannot be captured in the RECS lighting end use, torchiere energy is unaccounted for and therefore included in the "other" or miscellaneous end use. Since the AEO97 forecast is based on the RECS end use definitions, the AEO97 forecast for miscellaneous electricity also implicitly includes the torchiere lamp.

METHODOLOGY

We developed a bottom-up model comprised of over 90 individual product types of varying importance (Appendix C). The study includes saturations and unit energy consumptions (UECs) for each product type over the period 1976 to 2010. Total miscellaneous electricity consumption is the summation of the energy use for each product type.

Data on miscellaneous electric uses is sparse, and in some cases simply non-existent. Developing a detailed bottom-up estimate entailed assembling appliance stock data from disparate and sometimes obscure sources, conducting a metering campaign to derive estimates of average product power, and making engineering estimates of consumption when alternative methods were unavailable. The approach used in this study is best classified as "back-of-the-envelope".

The methodology used in this study differs from past analyses of miscellaneous energy use. Other studies estimate the miscellaneous end use using conditional demand analysis, engineering simulation models, or some combination of these two approaches (the statistically adjusted engineering model) (Belzer and Wrench, 1997: US DOE, 1995a: Nore et al., 1994).

Historical Analysis (1976-1995)

Data Sources

This study is unique in its attempt to reconstruct a twenty year history of the U.S. residential miscellaneous end use. Annual stocks are estimated using historic shipment data from *Appliance Magazine*, or reported saturations from Appliance Magazine and the U.S. Department of Energy's (U.S. DOE) Residential Energy Consumption Survey (RECS) Household Characteristics 1987-1993 (Appliance Magazine, 1986: Appliance Magazine, 1996a: US DOE, 1995b: US DOE, 1993a: US DOE, 1990a). Product lifetimes are either estimated or taken directly from Appliance Magazine or U.S. DOE Technical Support Documents. The wattage and usage figures for each product type are taken from a wide variety of sources (Appendix D).

Assumptions

Historical energy use is calculated assuming the following: 1) stocks in a given year are based on either shipment data or saturations; 2) stocks represent all existing products held by consumers regardless of usage; 3) the unit energy consumptions (UECs) of stock and replacement products are held constant through time (meaning that the efficiency and usage of a product bought in 1995 is assumed to be the same as that bought in 1976)[4]; 4) total energy use is the product of UEC and stock. All growth in miscellaneous energy use is attributed to either changes in the saturation of existing miscellaneous products, new miscellaneous products, or growth in the housing stock (since UECs were held constant).

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[4]This study is a first-order approximation of the miscellaneous electricity end use. UECs were kept constant over time since data needed to vary UECs are not available. Tracing the UECs of miscellaneous product is currently not possible given the limited availability of reliable data.

Calculating Stocks

Stocks are calculated using shipment data from Appliance Magazine when available (Appendix E). Calculating yearly stocks requires an estimate of the stock existing in 1976, yearly shipment data, average product lifetime, and a retirement function.

Estimating Existing Stocks

The existing stock in 1976 is taken directly from *Appliance Magazine* (Appliance Magazine, 1996b). If the saturation was not reported for 1976, we derive best estimates using saturations from later years (Appendix E).

Estimating Lifetimes

For the majority of product types, average lifetimes are taken from either Appliance Magazine or US DOE Technical Support Documents (Appliance Magazine, 1996b). The lifetimes are manufacturer estimates based on an assumed standard usage. For product types with a narrow range of usage across households, the average lifetime is applied to the national product stock. Examples include cordless phones, answering machines, televisions and VCRs.

The usage estimates for some appliances, particularly small housewares like blenders and waffle irons, seem high, and are uncertain. For example, AHAM (Association of Home Appliance Manufacturers) estimates that blenders are used 293 times a year. The average lifetime of a blender based on this usage is only seven years (Appliance Magazine, 1996b). With a lifetime of seven years, the calculated saturation of blenders (based on shipments and stock turnover) in 1995 is only 40% (Sanchez trial run using existing stock & new shipments 1976-1995). The published saturation of blenders is approximately 80% (Appliance Magazine, 1996b). The discrepancy between saturations results from the fact that not everyone (in fact very few people) use a blender 293 times a year. Many people may only use a blender once a month. When consumers use a product type less often than AHAM reports, the actual product lifetime is extended.

To estimate a representative lifetime, we chose a target saturation from Appliance Magazine. Using shipment data and the existing saturation, we estimated the lifetime that corresponds to the published saturation. For blenders, the calculated average lifetime was actually 14 years. We applied this methodology to product types that many people own, but infrequently use (hot plates, slow cookers, blenders and waffle irons). We also relied on this method when a published lifetime was not available, and in instances when we could not reconcile manufacturer lifetimes and shipment data with known saturations (compact audio systems and fans) (Appendix E).

Retirement Functions

Two linear retirement functions are used to calculate stocks. We assume that the existing stock in 1976 retires at the rate of 1/lifetime. If the lifetime is 10 years, each year $\frac{1}{10}$ of the stock existing in 1976 retires. At the end of the lifetime, 100% of existing stock is retired.

In any given year, the remaining stock of existing 1976 stock is calculated using the following retirement function described mathematically as follows:

$$S_{rm} = S_{1976} \times (1-(Y_{cur} - 1976)) / L \qquad \textbf{(Equation 1)}$$

S_{rm}: Existing 1976 stock still remaining in current year

S_{1976}: Existing Stock in 1976

Y_{cur}: Current year

L: Average product type lifetime (years)

The stock in any given year of surviving shipments (units shipped 1976 though current year) is calculated using the following linear equation described mathematically and logically as follows:

$$AGE = Y_{cur} - Y_{sh} \qquad \textbf{(Equation 2)}$$

AGE: Current age of a cohort of shipments

Y_{cur}: Current year

Y_{sh}: Year units were shipped

If $AGE < (\frac{2}{3} \times L) = \mathbf{TRUE}$

then, $SH_{rm} = SH_{or}$

If $AGE > (\frac{2}{3} \times L)\ \&\ AGE < (\frac{4}{3} \times L) = \mathbf{TRUE}$

then, $SH_{rm} = SH_{or} \times (2 - AGE \times 1.5 / L)$

If $AGE > \frac{4}{3} \times L = \mathbf{TRUE}$

then, $SH_{rm} = 0$

AGE: Current age in a given year of a cohort of shipments (defined above)

L: Average product type lifetime (years)

SH_{rm}: Shipments from prior year still existing in current year

SH_{or}: Shipments from original purchase year

In the second equation (applied to shipment data), no units in given age cohort retire in the first $\frac{2}{3}$ of their average life. All units are retired by $\frac{4}{3}$ of their average life (**Figure A-1**) (Koomey et al., 1998).

Total stock in any given year is the sum of the remaining 1976 stock still in existence and all shipments from 1976 through current year also still in existence.

Total stock is described mathematically as follows:

$$\mathbf{Stot = Srm + \sum_{1976}^{Y_{cur}} SHrm} \qquad \textbf{(Equation 3)}$$

S_{tot}: Total product stock in given year

S_{rm}: Existing 1976 stock still remaining in current year

SH_{rm}: Shipments from prior year still existing in current year

Y_{cur}: Current year

Alternative Method

If shipment data was not available, the product type stocks are calculated using saturations from Appliance Magazine or RECS 1987-1993 (Appliance Magazine, 1996b: U.S. DOE 1990a: U.S. DOE 1993a: U.S. DOE 1995a). The number of total U.S. Households for the period 1976 to 2010 are taken from the Statistical Abstract of the US, 1994 and Koomey et al., 1996b.

Total product type stock using this method is described mathematically as follows:

$$\mathbf{S_{tot} = P_{cur} \times HH_{cur}} \qquad \textbf{(Equation 4)}$$

S_{tot}: Total product stock in current year

P_{cur}: Saturation of product type in current year

HH_{cur}: Total U.S. Households in current year

National Energy Consumption by Product Type

We use an average usage estimate for each product type (Appendix D). Product usage is held constant for the time period 1976-1995. Using an average estimate prevents us from identifying trends in the usage of specific product types. For example, people may be using ceiling fans differently now than in the mid-1970s. Usage might be decreasing as people increasingly rely on air conditioning, or might be increasing if ceiling fans are substituted for air conditioning on borderline days. In many instances, these data are not available, and further research is needed.

We also use an average product wattage held constant over time (Appendix D). By holding wattage constant, we do not take into consideration individual product type trends such as the effect of increasing television screen sizes on product type energy use over time. In many instances, these data are not available.

Total energy is disaggregated into both active and standby energy consumption for all product types with a standby mode (Appendix F). For these product types, annual energy consumption is the sum of standby energy and active energy. By differentiating between active and standby consumption, we are able to estimate miscellaneous electricity standby consumption (or "leaking electricity") in the U.S.

For product types with no standby mode, the unit energy consumption (kWh/yr) is described mathematically as follows:

$$\mathbf{UEC = (P \times U) / 1000} \qquad \textbf{(Equation 5)}$$

UEC: Energy consumption in kWh/yr for a unit

P: Power in watts for a unit

U: Usage in hours per year for a unit

1000 converts watt-hours per year into kilowatt-hours per year

For product types with a standby mode, the unit energy consumption (kWh/yr) is described mathematically as follows:

$$\mathbf{UEC = ((P_{at} \times U_{at}) + (P_{st} \times U_{sb}) / 1000)} \qquad \textbf{(Equation 6)}$$

UEC: Energy consumption in kWh/yr for a unit

P_{at}: Active power in watts for a unit

U_{at}: Active mode usage in hours per year

P_{sb}: Standby power in watts for a unit

U_{sb}: Standby mode usage in hours per year

1000 converts watt-hours per year into kilowatt-hours per year

National product type energy consumption is described mathematically as follows:

$$\mathbf{E_{tot} = UEC \times S_{tot}} \qquad \textbf{(Equation 7)}$$

E_{tot}: Total national energy consumption for a product type

UEC: Energy consumption in kWh/yr for a unit

S_{tot}: Total product stock in given year

National Miscellaneous Electricity End Use Consumption

National miscellaneous electricity consumption is the sum of national consumption for each of the 90 individual end uses included in the study.

$$\mathbf{M_{tot} = \sum_{0}^{97} E_{tot}} \qquad \textbf{(Equation 8)}$$

M_{tot}: U.S. Miscellaneous electricity consumption

E_{tot}: Total national energy consumption for each product type

Example Calculation

To better convey energy calculations, we illustrate our methodology by calculating the energy consumption of blenders in 1977. The average lifetime of a blender is 14 years. In 1976, the stock of blenders was 36 million units.

Number of blenders existing in 1976 and still existing in 1977 equals:

36 million * (1-((1977-1976)/14))= 33 million

From 1976-1977, nine million blenders were shipped. Since the age of 1976 and 1977 shipments is less than 2/3 of lifetime, 100% of shipments survived. Total stock is the sum of surviving units and new shipments (42 million blenders in the U.S in 1977).

People use a blender 293 times per year, for a time period of five minutes per use. The average power of a blender is 300 watts. The unit energy consumption (UEC) of blenders equals:

300 W*(293*5/60)/1000 = 7 kWh/yr.

National energy consumption in 1977 is the product of UEC and stock (294 GWh).

The Miscellaneous Electricity Forecast (1996-2010)

This study uses three models to develop the miscellaneous forecast: industry, ARIMA, and subjective. Appliance Magazine publishes a five year forecast of product type shipments based on industry estimates of future growth (Appliance Magazine, 1997). For all product types included in the Appliance Magazine forecast, we use the industry projections for our forecast. For product types not included in the industry forecast, but that account for a substantial amount of miscellaneous energy, we use a statistical technique known as an auto regressive integrated moving average (ARIMA). We use LBL-REM projections for microwave ovens, clothes washer and dishwasher motors. For the remaining product types, we employ a subjective model to forecast future shipments or saturations. Time series plots for all product types are located in Appendix G[5]. Appendix E lists the forecast model used for each product type.

The difficulties associated with statistically derived energy forecasts are well documented (Freedman et al., 1983: Belseley, D., 1988: Shlyakhter et al., 1994). One method of addressing the issue of uncertainty is to bracket the possibilities of future energy use by developing high, predicted and low growth scenarios. Three scenarios are developed for most product types included in this study[6].

The degree of uncertainty in our forecasts varies by product type. The most difficult product types to forecast were either product types with limited data points or with shipments increasing or decreasing exponentially through 1995. Important product types (in terms of absolute consumption) with rapidly increasing shipments include halogen torchiere lamps, satellite systems, cordless phones, projection televisions, and VCR/TV combination units (Appendix G). With the exception of halogen torchiere lamps, we used industry estimates of projected shipments for our forecast. Our halogen torchiere forecast was developed after consulting members of LBNL's Lighting Systems Research Group of the Building Technologies Program who have expertise in this product area. Important product types (in terms of absolute consumption) with limited data points include pool pumps, spas/hot tubs, and well pumps. For these products, the number of data points was not sufficient to develop a reliable ARIMA model. Our forecasts for these product types are based on our subjective methodology described below.

Even using the most reliable estimates for future growth, projecting energy consumption is difficult due to the uncertainty and variability associated with forecast assumptions. Factors that can influence energy forecasts include economic growth, fuel prices, and growth in households. Influencing factors specific to our miscellaneous forecast include the convergence of currently separate product types such as televisions and computers or telephones and computers, changes in underlying technologies such as using switch-mode power supplies, the increasing number of remotely-controlled appliances, consumer demand and preference, and U.S. ENERGY STAR programs. Inability to foresee or predict these changes increase the uncertainty of our forecast.

The Industry Forecast

We believe that industry and manufacturer estimates of future shipments are more reliable and more insightful than any statistical model that we could generate. As a result, we rely on industry projections whenever available (Appliance Magazine, 1997). We applied our industry forecast methodology to 52 product types (Appendix E).

Appliance Magazine publishes a five year industry forecast of product type shipments (1997-2002). For these years, our study uses the industry data (we also have an actual data point for 1996). For the time period 2003-2010, we use a linear regression procedure to extrapolate future shipments. Our methodology is as follows:

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[5]The upper line on each graph represents our high growth scenario, the middle line is our predicted scenario, the lower line is the low growth scenario.

[6]We did not develop a high-low scenario for products for which we had limited stock data that were best estimates with little verifying/supporting documentation. Example end uses include instantaneous hot water, home medical equipment, grow lights and heat tapes.

1) Assemble 26 year time series of each product type shipment data (1976-2002)

2) For each product type:
   Identify specific time series within the 26 year data (1976-2002) that most likely[7] represents future growth trend.

3) Perform a simple linear regression based on chosen time series and use the regression equation to project shipments or saturations for the time period 2003-2010. This is the predicted scenario

4) Beginning in year 2000 and continuing through 2010, the high growth scenario is +20% of the predicted scenario and the low growth scenario is -20% of the predicted scenario. For the years 1996-1999, data points in high growth and low growth scenario were interpolated using a simple linear decline between year 2000 data point (calculated as described above) and 1995 data point.

ARIMA Modeling

We use ARIMA (autoregressive integrated moving average) models to model shipment and saturation data as univariate time series. ARIMA is a standard time-series modeling procedure, comprehensively discussed by Box and Jenkins (1976). We then use our ARIMA models to forecast shipments or saturations from 1996 through 2010. We developed ARIMA models for eight product types (Appendix E).

Future energy use was bracketed according to the following method:

1) Beginning in year 2000 and each year through 2010, the high growth scenario was estimated as predicted energy use +20%. The low growth scenario was estimated as predicted energy use -20%.

2) For the years 1996-1999, data points in each scenario were interpolated based on a simple linear decline between 2000 estimated shipment data and 1995 shipments .

The Subjective Model

The subjective model is basically just a series of educated estimates about future trends in shipment data based on time series plots. Educated guesses are founded on common sense, some general knowledge about the individual end uses studied, as well as patterns of product adoption and decline. We applied our subjective forecast methodology to 27 product types (Appendix E).

The following methodology summarizes our subjective model:

1) Assemble 20 year history of end use shipment data or saturation

2) For each end use, identify three trends in data based on the following information:
   predicted growth: identify specific time series within the 20 year data that most likely represents future growth trend.

[7]The word likely refers to educated estimates that are founded on common sense, some general knowledge about the individual end uses studied, as well as patterns of product adoption and decline. Educated estimates were made by the authors and researchers specific to an individual product type area.

high growth: identify specific time series within the 20 year data that represents a scenario of high growth that we do not think will occur, but may based on this previous growth trend in the 20 year data.

low growth: identify specific time series within the 20 year data that represents a scenario of low growth that we do not think will occur, but may based on this previous growth trend in the 20 year data.

3) For each scenario, perform a simple linear regression based on chosen time series and use the regression equation to project shipments or saturations for the time period 1996 to 2010.

Halogen Torchiere Lamps and Home Office Equipment

Halogen torchiere lamps are the most difficult miscellaneous product to forecast. Though torchiere lamp sales have skyrocketed in the past five years, the associated fire hazard has become increasingly publicized. While a future ban cannot be predicted, we can (at least) imagine one. Our assumptions about the future torchiere stock are as follows:

1) Low Growth scenario-Stock is capped at 60 million in year 2000 and held constant for the time period 2000 to 2010.

2) Predicted Growth scenario-Stock is capped at 100 million in 2005 (~1/household) and held constant for the time period 2005 to 2010.

3) High Growth scenario-Stock is capped at 125 million units in 2005 and held constant for the time period 2005 to 2010.

The future stock of home office equipment product types are forecasted using equipment growth rates for total industry sales (Koomey et al., 1995). The growth rates were then applied to the 1995 residential office equipment stock. Six product types were included in the office equipment forecast.

Incorporating New Products into our Forecast

We adjusted our forecast upwards to account for new product types (product types with no existing saturation or shipments in 1995) that may penetrate the market during the period 1996 through 2010. We disaggregated our forecast into two variables, growth from new product types and growth from increasing stocks of existing product types (increasing existing stocks are attributed to increases in product type saturation, or growth in total number of households). While we calculate growth from increasing existing stocks using our model, we are (of course) unable to precisely predict growth from new product types. We use the relationship between new product types (product types with no existing saturation or shipments in 1976) and increasing existing stocks from our historical analysis to adjust our forecast upwards[8].

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[8]It is impossible to accurately predict the emergence of new product types through 2010. From our historical analysis, we found that 17 new product types appeared on the consumer market during the time period 1976 to 1995. If in 1976, an analyst developed a forecast that began in that year and extended through 1995, the analyst would have missed the emergence of cordless phones, home office equipment including fax machines, copiers and multi-function devices, halogen torchiere lamps, home satellite systems, and TV/VCR combination units. Similarly, we are unable to foresee new product types that will

From 1976-1995, the relationship between existing stock growth and energy growth from new product types was 4:1, meaning that for every four TWh of growth from existing stocks there was one TWh of growth from new products. We assume that this relationship is constant over time and adjust our aggregate forecast accordingly. The forecast that results from this adjustment is referred to as the LBNL predicted scenario-adjusted for new product types. Our forecasted end use growth rate and absolute growth used in our comparison with AEO97 includes the new product types adjustment since from an overview perspective, accounting for new products provides a better estimate of total projected growth. However, our breakdown of forecasted miscellaneous growth into individual product types does not include new product types since this is only calculated as an aggregate sum.

We use the LBNL-predicted scenario adjusted for new product types when we discuss our forecasted growth for the entire miscellaneous electricity end use. This scenario is used in the Results "Overview" section when stating the forecasted growth for the period 1996-2010 as well as the projected 2010 consumption estimate. We do not use the forecast adjusted for new product types (we use the LBNL predicted scenario) when we discuss projected growth and consumption *by end use category* and *by top ten product types* for the period 1996 to 2010. For these cases, when we state the percent of total projected consumption and growth attributed to end use categories and individual product types, we are only comparing to projected growth from existing 1995 product types (not adjusted). We have clearly labeled all graphs to reflect which scenario is being represented.

Ranking Potentials

The ranking portion of the analysis focuses on identifying the largest and fastest growing miscellaneous product types.

To identify the largest individual product types, we disaggregate the miscellaneous end use into four end use categories: motors, electric resistance heating, consumer electronics and lighting. Some of these end uses do not fit neatly into a single end use category. For example, hair dryers have both a motor and heater. In these cases, we determine the most energy intensive component of the appliance. From an energy perspective, the heating element is more important in a hair dryer than the small motor. In future detailed analyses of cost-effective potentials, it may be necessary to disaggregate energy use by technology within certain individual product types.

We identify the largest individual product types within each end use category. Within the entire miscellaneous end use, we identify the top ten product types in 1976, 1995 and those projected in 2010. We also note the top ten growing product types for the periods 1976-1995 and projected in the period 1996 to 2010.

RESULTS

Overview

Miscellaneous electricity is one of the fastest growing residential end uses. Results from our historical analysis show that from 1976 to 1995, miscellaneous electricity consumption increased at an annual rate of 4.6%. Our results show that in 1995, miscellaneous

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emerge between the years 1996 and 2010. As an aggregate sum, we attempt to adjust our forecast to reflect new products.

electricity consumption totaled 235 TWh[9], approximately one quarter of U.S. residential electricity use. Miscellaneous electricity was the largest residential electricity end use, consuming nearly twice as much energy as either the electric heating, cooling, or refrigeration end uses. The projected growth rate over our forecast period, 1996 to 2010, for the LBNL predicted scenario-adjusted for new product types is 2.7%/yr. Though the projected miscellaneous growth rate is lower compared to the historical analysis, it is much greater than the aggregated growth rate for all non-miscellaneous electricity end uses (**Figures A-2 and A-3**).

Our study projects that from 1996-2010, miscellaneous electricity consumption will increase 115 TWh, accounting for over 90% of future residential electricity growth. Low growth rates for non-miscellaneous end uses explain the substantial fraction of future growth attributed to miscellaneous uses[10]. Of the 90 product types included in our study, ten product types alone account for over half of current consumption (1995) and forecasted growth (1996-2010) (**Tables B-1 and B-2**).

Miscellaneous Electricity Use: 1976-2010

Miscellaneous Electricity: 1976

In 1976, the miscellaneous end use was dominated by the motor and heating end use categories. Motor and heating energy use totaled 43 TWh and 33 TWh respectively. Together, these two categories accounted for over 75% of total miscellaneous electricity use (**Figure A-4**: **Tables B-3 and B-4**). Seven major product types were responsible for over 80% of heating electricity use (**Tables B-5a,b**). Only nine product types accounted for 90% of motor energy (**Tables B-6a,b**).

Home entertainment product types accounted for 15 TWh of consumer electronics energy consumption (roughly 70%). Entertainment end uses included television sets and audio systems. The remaining 30% was attributed to practical devices such as doorbells, clocks and small table radios (**Table B-7a**). In 1976, consumer electronics totaled 23 TWh, roughly one quarter of all miscellaneous electricity consumption (Figure A-4).

In 1976, our miscellaneous lighting component consisted of only grow lights since the halogen torchiere lamp did not comprise a large component of home lighting (Figure A-4).

Miscellaneous Electricity 1976-1995

The growth in the miscellaneous end use from 1976-1995 was largely due to the growth in the consumer electronics end use category. From 1976-1995, consumer electronics increased at a rate of 7%/yr. (**Figure A-5**, Table B-4). Absolute growth of consumer electronics during this period equaled 64 TWh, nearly half of all miscellaneous growth.

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[9]According to 1993 Household Energy Consumption and Expenditures report published by U.S. EIA, annual electricity use per household equals 9,965 kWh/yr. Based on this number, one TWh of electricity will serve roughly 100,000 U.S. households. One TWh is also equivalent to $60 million in annual consumer expenditures with carbon emission equivalent to 0.31 million metric tons carbon (MtC), roughly the carbon emissions from 65,000 cars.

[10]Forecasted growth rates for refrigerators and freezers are negative, in large part because of the effectiveness of minimum efficiency standards applied to these two end uses (see Koomey et al. 1998 for details).

Due to both its rate and magnitude of growth, consumer electronics became the dominant miscellaneous end use category by 1995 (87 TWh).

During this period, consumers adopted the microwave oven, and basic home entertainment was displaced by more luxury items including multiple color television sets, cable television and video cassette recorders. From 1976-1995, the energy consumption of these four product types increased 40 TWh. These end uses accounted for 60% of consumer electronics growth. Nearly 10% of total residential electricity growth over this period was attributed to enhanced home entertainment and microwave ovens (**Table B-7b**)

The growth in miscellaneous lighting is due to the emergence of halogen torchiere lamps which grew at a rate of 20%/yr. (Figure A-5, Table B-4). Most growth in this end use category occurred only after 1990 when sales of torchieres rapidly increased. If you consider that most growth occurred in just five years, the actual end use growth rate is over 200%/yr. In 1995, the energy consumption of halogen torchieres totaled 11 TWh.

Again, our miscellaneous lighting category includes products types that are not captured in EIA's conventional lighting end use. Even though torchiere lamps are a lighting end use, they are treated as a miscellaneous product type by our definition-for the purpose of model comparison. Torchiere lamps appeared after 1990, and the corresponding energy use was accounted for in the 1993 RECS miscellaneous or "other" end use category. Because AEO uses a miscellaneous growth rate calculated with the 1987-1993 RECS "other" end use consumption numbers, their growth rate includes the emergence of halogen torchiere lamps. Our data shows that roughly 9% of historical miscellaneous growth was due to these lamps, making this product a substantial amount of AEO's forecasted miscellaneous growth. By grouping torchieres in the miscellaneous end use, we do not evaluate the possible energy offset due to the decline in energy from non-torchiere lamps.

During this period, the overall importance of the motor and heating end use categories declined. The growth rates of motors and heating were comparatively lower, 2.8%/yr. and 3.3%/yr. respectively (Figure A-5). Cumulatively, these two categories were responsible for 44% of total miscellaneous growth. Though energy use by these two categories increased, their total share of miscellaneous electricity declined.

Miscellaneous Electricity 1996-2010

From 1995-2010, we predict that the lighting component of miscellaneous electricity will grow at a rate of 8%/yr. (Figure A-5: Table B-4). The absolute growth for this period equals 28 TWh and accounts for one third of future miscellaneous electricity growth. Nearly all future growth in lighting is due to the halogen torchiere lamp. The difficulty associated with forecasting the torchiere lamp stock was previously discussed in the methodology section. If torchieres are removed from the miscellaneous end use, our estimated future miscellaneous growth rate is 1.7%/yr (originally 2.2%/yr). AEO97 is an aggregate energy forecast, so we are unable to disaggregate the portion of forecasted AEO growth that is due to the torchiere lamp.

Growth in consumer electronics is lower in the forecast years compared to historical rates. The future growth rate is 2.5%/yr. with an absolute increase of 38 TWh (42% of total miscellaneous growth). In 2010, energy use from electronics will increase to 125 TWh accounting for 35% of total miscellaneous electricity.

In our forecast, consumers are expected to purchase projection televisions or the TV/VCR combination, satellite dishes, and compact audio systems. Energy use of these four emerging product types (sales primarily increased after 1990) is expected to be 22 TWh in

2010. From 1996 through 2010, we project that energy from these products will increase 14 TWh, accounting for over 40% of consumer electronics growth.

From 1996-2010, the energy shares of motor and heating end uses continue to decline. Motors and heating have low future growth rates (1.5%/yr for motors and 0.6%/yr. for heating). Motor end uses account for 22% of future miscellaneous growth and heating end uses only account for 6% of projected growth (Figure A-5, Table B-4).

Priority Product Types: Absolute Consumption and Growth

Results from this study may be used as a guide for identifying high priority end uses for future research and public information efforts. The remainder of this section identifies 1) the largest individual end uses in each major end use category 2) the largest individual end uses within the entire miscellaneous end use 3) the end uses with the largest historic growth (in terms of absolute consumption), and the greatest potential for future growth.

By End Use Category

Heating

The end use breakdown of the heating category has been relatively constant through time. This category consists of eight major product types representing approximately 85% of total heating electricity use. Targeting large product types for efficiency programs is simplified by the fact that this category has not changed drastically over time (Tables B-5a,b).

Motors

The end use breakdown of the motor category has been relatively constant through time. Ten product types account for nearly 90% of all miscellaneous motor electricity use. Targeting product types for efficiency programs is simplified by the fact that this category has not changed drastically over time (Tables B-6a,b).

Consumer Electronics

The evolution of the consumer electronics end use category is shown in Tables B-7a,b,c. These tables list the most important product types by year. These product types are listed in prioritized order according to total energy use. Unlike heating and motors, the product composition of this category has changed over time. The individual importance of larger product types within this category has similarly changed.

Lighting

The halogen torchiere lamp is responsible for nearly all lighting energy use.

Top Ten Miscellaneous Product Types

Large Product Types 1976-2010

Top ten product types for the years 1976, 1995 and projected 2010 are presented in **Tables B-8a,b,c**. In 1995, the top ten product types accounted for over half of total miscellaneous electricity consumption.

Over 20 new products were added to the miscellaneous end use from 1976-1995. Many of these devices, like cordless phones, are small and have low UECs but frequently high saturations (excluding torchieres). Because many of these devices are small energy users and inexpensive to purchase, they are hard to target for efficiency programs. This study found that the aggregate energy use of these small devices is being offset by the increasing energy use of a few large product types. From 1976 to 2010, the percentage of total miscellaneous electricity attributable to the ten largest product types has remained between 50-55%. Miscellaneous electricity use over time is being dominated by a few large product types.

Top Ten Growing End Uses

The top ten growing product types are listed in **Tables B-9a,b**. From 1976-1995, consumer electronics accounted for nearly half of top ten product growth. From 1996-2010, halogen torchiere lamps will account for nearly 30% of top ten growth.

Growth in miscellaneous electricity is being driven in large part by only ten product types. From 1976-1995, the top ten product types accounted for over 64% of all miscellaneous growth. The ten largest growing product types are expected to account for 60% of total forecasted miscellaneous growth from 1995-2010.

Model Comparison: LBNL Research Results and EIA's End Use Estimate

RECS

EIA's Residential Energy Consumption Survey (RECS) provides an alternative method for estimating miscellaneous end use consumption. This section summarizes the RECS end use estimation methodology and compares RECS results to LBNL's bottom-up estimates.

RECS estimation methodology

RECS is a national survey which has been conducted every three to four years since 1984.[11] The survey collects household level data on housing and occupant characteristics in conjunction with fuel sales data collected directly from suppliers. These data are used to estimate fuel consumption by end use at the household level. The household level estimates are subsequently used to derive estimates of end use consumption nationally. Since the 1984 survey, EIA has used non-linear regression to estimate end use consumption, using a separate equation for each fuel type (Residential Energy Consumption Survey Quality Profile, p. 121).[12] The exact method used for end use consumption estimates has changed a little with each survey year. For the 1993 survey, nine separate equations were used for electric end use estimation: space heating, air conditioning, water heating, refrigerators, freezers, lighting, cooking, dishwashers, clothes dryers, as well as an additional "all other appliances" component. (U.S. DOE, 1996c: p. 115). Consumption for the 1993 "all other appliances" component was estimated on the basis of both specific equipment holdings (televisions, hot tubs, etc.) as well as general household variables (number of members, heated square footage of house) which are meant to serve as proxies for miscellaneous electric end uses not directly accounted for

[11]A predecessor survey was conducted by EIA annually between 1978 and 1982.

[12]The regression-based estimates are normalized, so that the consumption estimates for each component add up to the measured total fuel consumption.

elsewhere (source: U.S. DOE 1995a; personal communication, Robert Latta, 20 November 1997).

Comparison

We compared our estimates of the miscellaneous end use to RECS estimates for three survey years, 1987, 1990, and 1993 (US DOE, 1990b; US DOE 1993b; US DOE 1995b). To derive a consistent definition of "miscellaneous" end use for comparison purposes, we used RECS-based estimates of national "Appliance" total consumption less the consumption estimated for ranges, freezers, clothes dryers, and lighting.[13] **Table B-10** summarizes the RECS/LBNL comparison for the three survey years. The RECS and LBNL estimates are fairly close for each survey year, with a maximum difference of 19%. This agreement is impressive especially considering how disparate the two methodologies are: wherein the LBNL estimates rely on estimates of stock, usage, and metered or engineering estimates of power consumption for individual appliances to build up aggregate estimates, the RECS estimate is derived from a disaggregation of measured household energy consumption for a statistical sample of households. But for detecting trends, the pointwise differences in RECS and LBNL estimates lead to very different results: 11.4% per annum growth rate for RECS, as compared to a 4.1% per annum growth rate from LBNL estimates.

For each of the two estimation methods, LBNL's and the one used with RECS, there are several possible explanations for the changes in the miscellaneous end use consumption estimates across the three survey years. The changes in consumption estimates may in part reflect real changes in miscellaneous end use consumption. But the observed changes may also, at least in part, be artifacts. For the RECS estimates, such observed but artificial changes include unavoidable statistical sampling error, changes in sample size and sample composition, variations in weather,[14]and probably most importantly, changes in estimation methodology. EIA's end use estimation methodology has been updated and improved each survey year.[15] For example, in the 1990 RECS, the electrical appliance category was divided into refrigerators, freezers, and all other appliances for the purposes of deriving end use consumption estimates. However, in RECS 1993, appliance end use consumption was further subdivided, with additional separate estimation categories (lighting, cooking, clothes drying, and dish washing) as enabled by the more detailed data collected from each household (U.S. DOE, 1996c: p. 118).[16] Between 1990 and 1993, RECS estimates of miscellaneous end use consumption increased by 50%.

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[13]As reported in Table 3.1 (1993 RECS C&E, p. 10), Table 2 (1990 RECS C&E, p.10), Table 3 (1987 RECS C&E, p. 10). For the 1987 estimate, we also subtracted refrigerator consumption for the "Appliances" consumption total; in 1990 and 1993 the refrigerator component was estimated separately, so no adjustment was necessary.

[14]To the extent that the end use consumption model does not perfectly account for weather, changes in weather can influence the allocation of fuel consumption into end use estimates, all other things being equal.

[15]See Residential Energy Consumption Quality Profile (1996), pp. 118-121, for discussion of some of these changes.

[16]The "all other appliances" category remained, but represented a reduced set of end uses relative to the 1990 survey.

The 1993 figure may be a better estimate of true miscellaneous end use electricity consumption than the 1990 figure, though of course it is unlikely that miscellaneous end use consumption itself rose by 50% in three years. For trend-oriented research, it is difficult to untangle the impact of methodological and other artifactual changes from the measurement of actual changes in usage, thus complicating the process of forecasting on the basis of RECS end use consumption estimates. Therefore LBNL's estimates provide a useful comparison and cross check to RECS estimates.

AEO97

1995 Comparison

The development of the AEO97 forecast is based on trends in miscellaneous energy use calculated from the historical RECS data. Forecasting on the basis of RECS end use consumption estimates is complicated since observed growth reflects both real changes in consumption as well as changes due to weather, sampling and methodology. The AEO estimate for 1995 miscellaneous electricity consumption is 337 TWh (compared to our estimate of 235 TWh). A fraction of the difference in the 1995 estimates is due to the dissimilar growth rates used in the AEO97 and LBNL models for the time period 1993 to 1995. EIA used a growth rate of 7.5% per household over this period and through 2000. The attained growth for the period 1993 to 1995 was 8.8%. The growth rate calculated in our study from 1993 to 1995 was much lower, 3.2% per year[17] (**Figure A-6**).

1996-2010 Comparison

Our study shows a lower forecasted growth rate for miscellaneous electricity than that reported in AEO97. The annual growth rate of our predicted scenario adjusted for new products is 2.7% while AEO's growth rate over the same period is 3.8%/yr. This difference in growth rates results in dissimilar projections of absolute growth (TWh) from 1996 to 2010. Our forecasted growth is 115 TWh, which is 55% lower than the projected absolute growth in the AEO97 forecast (255 TWh).

Standby Energy Consumption ("Leaking Electricity") in the U.S.

Appliance standby energy consumption equals 43 TWh/yr, roughly 20% of residential miscellaneous electricity consumption (Appendix F). The standby mode performs one or some combinations of the following services: maintaining an internal clock or memory, maintaining signal reception capability, maintaining battery charge, and displaying settings. Transformer losses also increase standby power consumption (Huber, 1997). Consumer electronics product types account for 98% of total standby energy consumption[18]. Because

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[17]The AEO97 forecast is based on trends in historic RECS data. The miscellaneous growth rate calculated from the historic RECS data (1987-1993) is 11.4%/yr. The AEO97 model scales that growth rate down (since 11.4% likely includes both real and artifactual changes). However, the estimated EIA growth rate of 7.5% per household is still much higher than the growth rate we calculate using historic shipment data. We note that some miscellaneous energy and growth may not be captured in our model since we do not include every possible miscellaneous electrical use in a home, we do not include a SEDS adjustment, and or unit energy consumption does not vary over time to reflect changing energy patterns within individual product types.

[18]Non-consumer electronics product types with standby power considered in this study include men's and women's shavers and electric toothbrushes.

of the number of electronic product types with standby modes, the hours operated in standby mode and the power used to provide the services, the amount of electricity "leaking" from consumer electronics is quite high. In 1995, nearly half of all electronics energy was consumed while in standby mode.

Of particular interest are three product types for which we anticipate substantial future growth: compact audio systems, satellite systems, and security systems. Energy from these three product types is expected to account for 35% of all future consumer electronics growth. For all three products, it is difficult (from an energy perspective only) to tell "on" from "off". In active mode, the compact audio system draws 15 W. In standby mode, the compact audio system draws an average of 11 W. The standby power and active power of satellite systems is only negligibly different (14 W standby, 15 W active). A similar on to off ratio exists for security systems (18 W off 22 W on). Satellite systems and compact audio systems alone are projected account for nearly one quarter of forecasted consumer electronics growth.

ENERGY EFFICIENCY OPPORTUNITIES TO REDUCE MISCELLANEOUS ELECTRICITY CONSUMPTION AND GROWTH

Reducing U.S. Standby Energy Consumption

Given the historical and forecasted importance of electronics, focusing on lowering standby power consumption is one method of reducing miscellaneous growth. While acknowledging the convenience of services such as remote control, we believe that these same services can be provided with substantially less power. Several design options are currently available to reduce standby consumption: using flash memory to maintain programming/settings, using more efficient components in the circuit design, or using a switch mode power supply for product types with wall packs (answering machines, cordless phones) (Thorne and Suozzo, 1998, Webber, 1997).

For most product types, we believe that standby power can be reduced to one watt or less. In a recent metering campaign, we found 31 product types with at least one unit at or under one watt (approximately 10% of our sample) (Webber, 1997). Even among product types that consumed the most in standby mode, we found at least one efficient model. For example, one compact audio system was metered with a standby power of 28 W while another model (with similar features and capabilities) was metered with a standby loss of only 2 W (Huber, 1997).

A "1 watt standby power" labeling program is currently under consideration by policy makers in the U.S**.** A program that reduced all standby power consumption in residential appliances to one watt per unit has the potential to reduce U.S. standby consumption to 22 TWh, nearly a 50% reduction from current levels[19]. By focusing only on standby losses, U.S. miscellaneous electricity consumption would be reduced by 21 TWh, saving roughly $1-2 billion annually (**Table B-11**).

Torchiere Replacements

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[19]The 1-W savings assumes that in 1995, every appliance (except home office equipment and TVs and VCRs) has a standby power of only 1-W. Savings are the difference between current consumption and the consumption at 1 Watt. Savings are not the result of a replacement/retirement calculation over time. We decided not to include home office equipment or TVs and VCRs in our calculation since they have their own Energy Star product labeling program (Energy Star TVs and VCRs and Energy Star Office Equipment).

Energy efficient CFL torchieres are currently available (Siminovitch et al. 1997). The CFL torchiere uses two 36 watt CFLs driven by one ballast. The total plug wattage of these lamps is 65 watts compared to the 300 to 500 watt halogen models. If all new torchieres sold between 1996 and 2010 were compact fluorescent, projected growth will be reduced by 21 TWh, saving approximately $1-2 billion annually. In response to the growing concern over fire safety, the CFL torchiere can be marketed as a safer alternative to the halogen model.

Furnace Fan Improvements

Furnace fans consume a large fraction of currently defined miscellaneous energy (21 TWh, nearly 10%). Several options exist to improve the efficiency of furnace fans including: changing motors from the most-common permanent split capacitor (PSC) to permanent magnet (also known as electronically commutated or ECPM) which have an inherent variable-speed capability, redesigning fan blades from the less-efficient forward-curved position to a backward-inclined design, and focusing on correcting adverse effects on fan performance due to inlet and outlet geometry. Improving all of these areas can result in 40% energy savings (8 TWh/yr) (Nadel et al. 1992).

MISCELLANEOUS TRIVIA

Women's Hair Products

Hair product types are a good example of the aggregated impact of individually small energy consumers. Assuming that a household owned each of these product types and used them on a regular basis, annual product energy consumption would total 47 kWh/yr, a negligible 0.5% of average annual household electricity use. However, when you consider that four out of five U.S. households owns a hair dryer (the most energy intensive hair product), total national electricity use is no longer so trivial. Assuming that all households with hair products use them regularly, end use consumption equals roughly 3.5 TWh/yr.

Aquariums

Whereas most pet owners incur costs due to vet bills and food supply, we found that the cost of fish ownership primarily shows up on the monthly utility bill. Of particular interest are reef tank owners whose tanks simulate the environment of a tropical coral reef. Reef tanks represent only one percent of all U.S. aquariums, but they account for one quarter of total aquarium electricity use.

Reef tanks are set up as a sump and pump combination system. One large pump (~150 Watts) returns water from the sump to the main tank. Another pump removes phosphorous, nitrogen and amino acids which prevents algae growth. Powerheads are installed to increase water movement. In order to recreate turbulent reef conditions, an electronic wavemaker is used to turn power heads on and off. The lighting requirement of an average tank is six watts per gallon (tanks are typically over 100 gallons). Tank lights are on a minimum of ten hours per day. Due to the heat generated by the enormous amount of lighting and the powerful pumps that circulate the water, reef hobbyists need to cool their tank. Cooling is accomplished by fans or an actual mini-AC unit attached to the tank.

The energy consumption of a typical 180 gallon tank is over 6000 kWh/yr. To put this number in perspective, the energy from a reef tank frequently exceeds the combined annual electricity consumption of a residential central electric heating system and a refrigerator. During our research, we encountered one fish owner who was seriously considering installing a wind powered generator just to power her fish house.

On the national level, we estimate aquarium consumption at four TWh/yr, making aquaria our twentieth largest miscellaneous end use. Reef tanks (1%) and non-reef salt water tanks (9%) are only a small fraction of U.S. aquarium stock. The energy use for the remaining ninety percent of tanks ranges from 150-400 kWh/yr. It is certainly worth noting that reef tanks and other marine tanks account for nearly half of total national aquarium energy use (Sanchez and Meier, 1997).

Electric Toothbrushes

The electric toothbrush is another end use for which shipments in the recent decade have increased. We suspect that this is due either to dentists' recommendations or their ticket to fame through the Seinfeld sitcom. Though not a large or high profile miscellaneous end use, keep in mind that these devices are typically plugged in all year. The energy "leaking" from electric toothbrushes each year is equivalent to carbon emissions from 12,000 cars.

The Truly Miscellaneous

We compiled a list of all end uses considered to be "truly" miscellaneous in nature (Appendix H). These end uses are considered extraneous by even the most devoted energy analysts. In 1995, energy consumption of these end uses total 24 TWh, roughly 10% of all miscellaneous electricity. Though we do not foresee any energy programs targeting products like hot air corn poppers and foot massagers, we still want to note that it takes nearly three 1000 MW nuclear power plants to generate the electricity to operate these little electric devices.

LIMITATIONS TO THE STUDY

Uncertainty in the Stock Data

Data problems can be grouped into two broad categories: information gaps (either due to missing data or changes in the method of reporting data) and disagreements within and between data sources.

Reviewing *Appliance Magazine* shipment and saturation data revealed both missing data as well as methodological changes. From 1976-1980, rack audio systems were tracked through the sales of individual components. From 1988-1995, rack systems were accounted for in terms of saturation. No data was available for 1980-1988 (Appliance Magazine Statistical, 1986: Appliance Magazine, 1996a). In the case of RECS data, problems stemmed from the lack of a consistent list of household appliances surveyed. Electric blankets were included in 1987 but not in 1993 and aquariums were included in 1993 but not in 1990 or 1987 (RECS 1987a: RECS 1990a: RECS 1993a). Data problems resulted in a spotting of known shipments or saturations over time. In these cases, the unknown data was determined either through simple linear interpolation/extrapolation or on the basis of personal judgment.

For data that was given, we frequently encountered disagreements when trying to compare estimates from different data sources. RECS estimates the saturation of aquaria at 4% while a Pet Product Manufacturer Trade Association (PPM) survey estimates a 7% saturation (PPM, 1996). Part of this discrepancy can be explained by potential differences in the definitions of these products. In the case of aquaria, PPM may classify an aquarium as any tank above 5 gallons while RECS may have a more stringent definition based on tank equipment. Definition problems are specific to the miscellaneous end use and will most likely perpetuate into the future because of product characteristics.

Uncertainty in Product Unit Energy Consumption

In the past, miscellaneous electricity has been researched with limited effort. As a result, a relatively scarce amount of data has been compiled regarding miscellaneous product types. We encountered a lack of data regarding the unit energy consumption (UEC) of various product types (**Table B-12**). Many miscellaneous product types have a wide range of usage across households. Similarly, usage varies substantially by geographic region for product types such as fans, waterbed heaters, and pool equipment. In absence of metered information, our usage estimates on product types with a large usage range are uncertain and relatively crude.

It is also true that the power and usage of product types has changed over time and will likely continue to change in the future. Data to incorporate efficiency and usage issues into our time-series model is currently unavailable. Lack of data prevent the model from reflecting interesting and important trends within individual product types. As mentioned in our methodology section, this type of detailed analysis is beyond the scope of our study. UEC estimates are likely the greatest area of uncertainty in this study.

FUTURE RESEARCH

Additional research should focus on correcting some of the limitations in this study. For the most important product types identified in this report, a range on both wattage and usage could be incorporated into this study (Meier et al., 1992). This would at least acknowledge the variation and uncertainty associated with the miscellaneous end use.

Of the most important miscellaneous product types identified in this report, more work should be devoted to analyzing the technical potential for reducing the consumption of these products. A more detailed study would consider costs of efficiency improvements, a detailed analysis of end use efficiency options and program/policy recommendations necessary to actually achieve determined energy savings. This would similar to technical potential analyses completed for other major end uses.

CONCLUSIONS

In this study, we developed a bottom-up model of the miscellaneous end use. Using shipment data and a consistent stock accounting framework, we estimate the energy use of over 90 products over a 34 year period (1976-2010). Our results show that miscellaneous electricity is the largest residential electricity end use, consuming nearly twice as much energy as either the electric heating, cooling or refrigeration end uses. We project that over 90% of future residential electricity growth will be due to the miscellaneous end use.

In order to compare our results to estimates from AEO97, our definition is consistent with EIA's miscellaneous electricity definition. Using this definition, some product types are included in the miscellaneous end use even though they belong in more conventional end use categories. Examples of potentially mis-classified product types include microwave ovens, clothes washer and dishwasher motors, evaporative coolers and ceiling fans. Our study also shows that miscellaneous electricity includes the energy use from new product types that have not been incorporated into conventional categories. For this reason, halogen torchiere lamps are included in the study.

Our estimate of current (1995) miscellaneous consumption as well as forecasted miscellaneous growth is lower than estimates published in AEO97. AEO97 estimates 1995 miscellaneous consumption at 337 TWh compared to our estimate of 235 TWh. A portion of this difference is due to dissimilar growth rates used from 1993 to 1995. The growth rate used by EIA is 7.5% per year per household compared to our growth rate of 3.2% per year calculated from the historic shipment data. Our forecasted growth rate including new products (1996 to 2010) is also lower, 2.7% compared to EIA's growth rate of 3.8%/yr.

Our results show that only ten product types account for over half of current miscellaneous consumption and forecasted miscellaneous growth. Consumer electronics growth accounted for nearly half of total growth from 1976 to 1995. Our forecast projects that 70% of future miscellaneous growth will be due to consumer electronics and halogen torchiere lamps. 43 TWh of current miscellaneous use is due to standby consumption.

One efficiency opportunity in the miscellaneous end use is to reduce standby power on all product types with a standby mode. Because only a small number of miscellaneous product types account for a majority of consumption, target efficiency programs can have a substantial effect. Product types with large efficiency potentials include halogen torchiere lamps and fans for fuel-fired furnaces.

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APPENDIX A: REPORT FIGURES

This section contains the complete set of figures referred to throughout the report. To increase the readability of the report, we chose to include all figures in this appendix.

Figure A-1: Appliance shipments survival curve used in this analysis

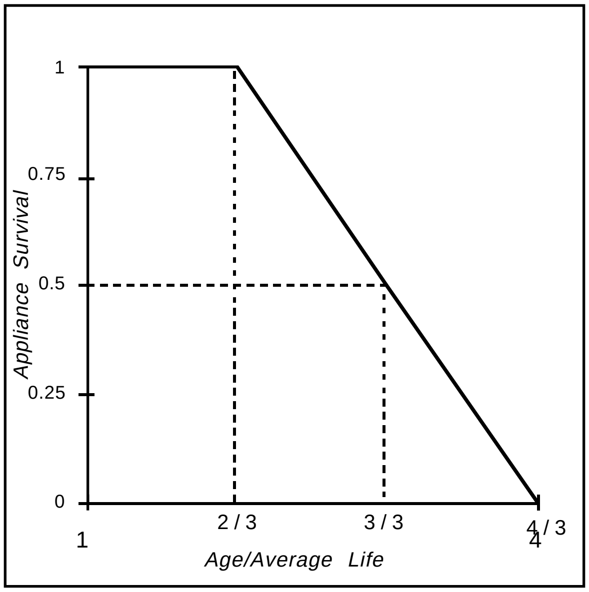
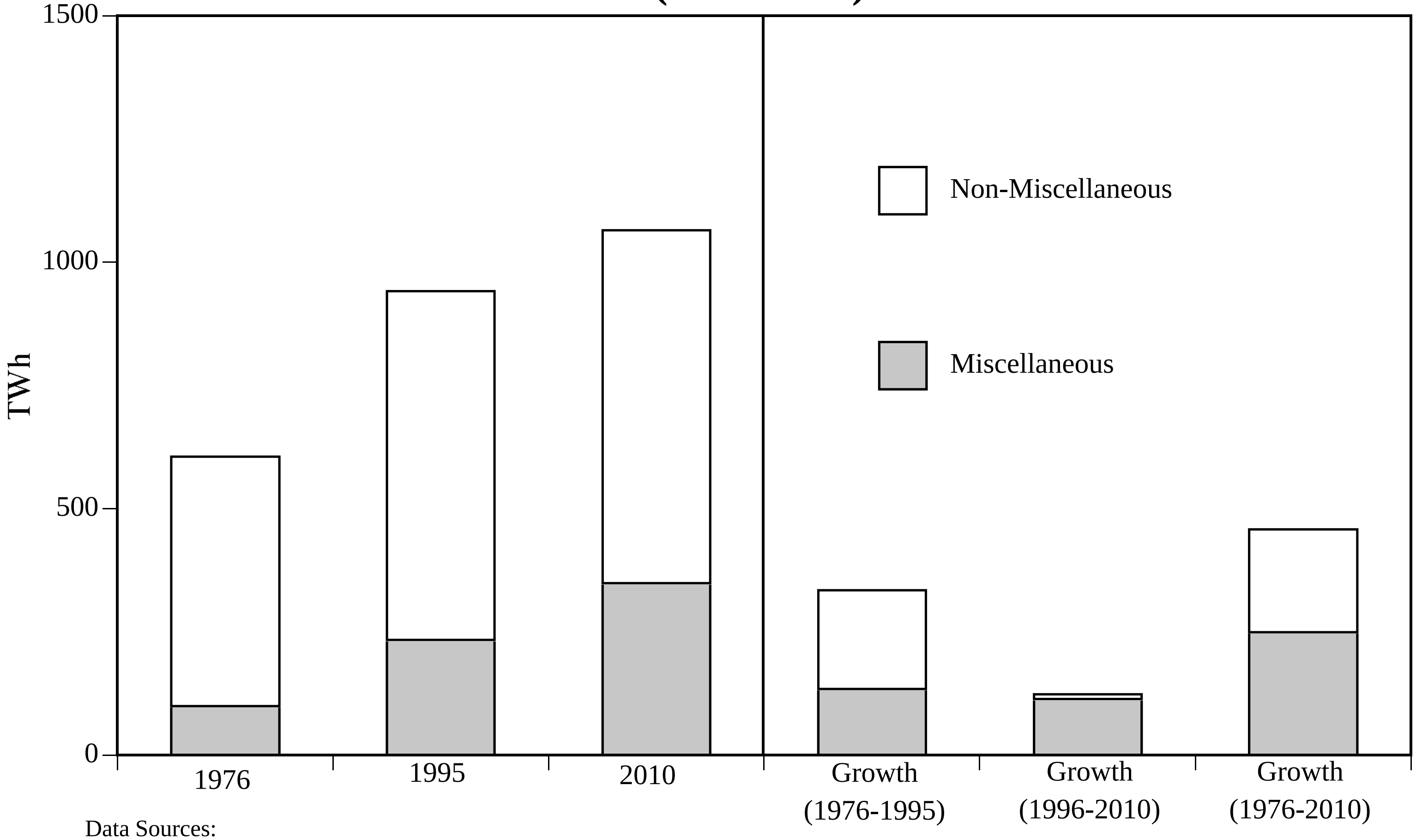


Figure A-2: Total Electricity Use in the Residential Sector (1976-2010)



Data Sources:

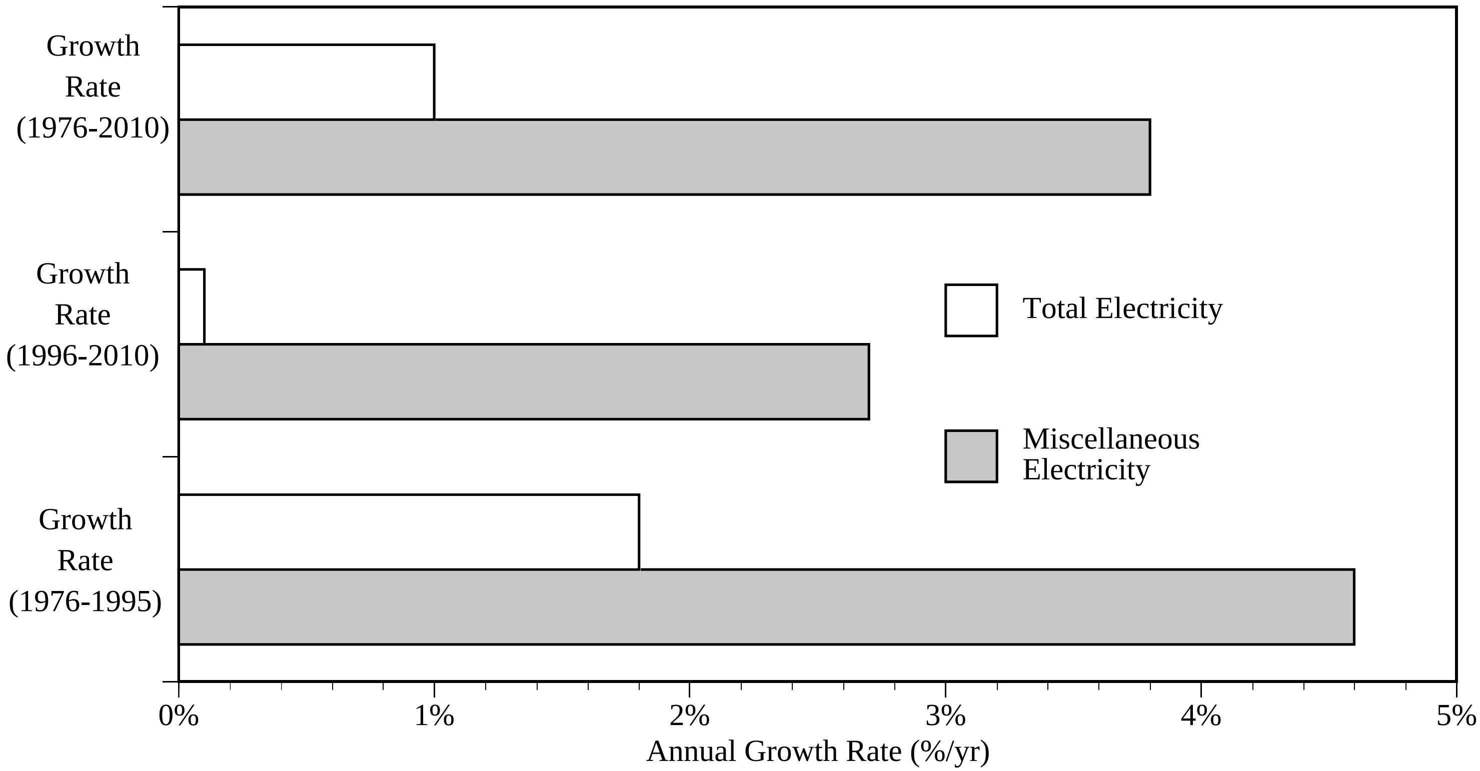
1976: Total Residential Electricity=Pierce 1994; Miscellaneous=Sanchez

1995 and 2010: Total Residential Electricity=AEO97; Miscellaneous=Sanchez

The projected estimate of 2010 miscellaneous consumption and forecasted miscellaneous growth from 1996 to 2010 include an adjustment for new products.

We adjusted our predicted scenario forecast to include growth from new products as described in our methodology.

Figure A-3: Growth Rate Comparison for Residential Electricity Use



Data Sources:

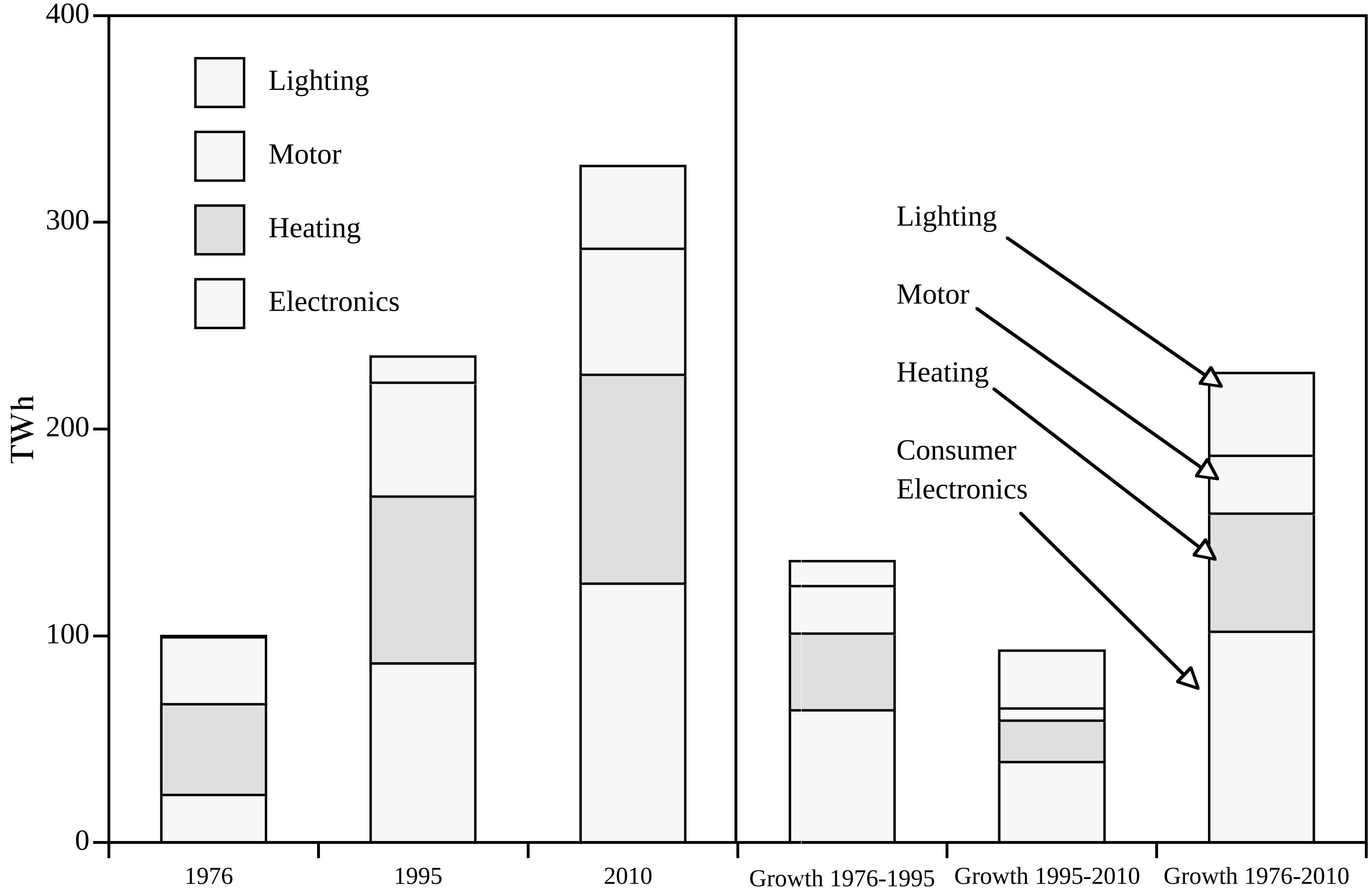
1976: Total Residential Electricity=Pierce 1994; Miscellaneous=Sanchez

1995 and 2010: Total Residential Electricity=AEO97; Miscellaneous=Sanchez

Our miscellaneous growth rate from 1976 to 2010 and 1996 to 2010 includes an adjustment for anticipated new products growth

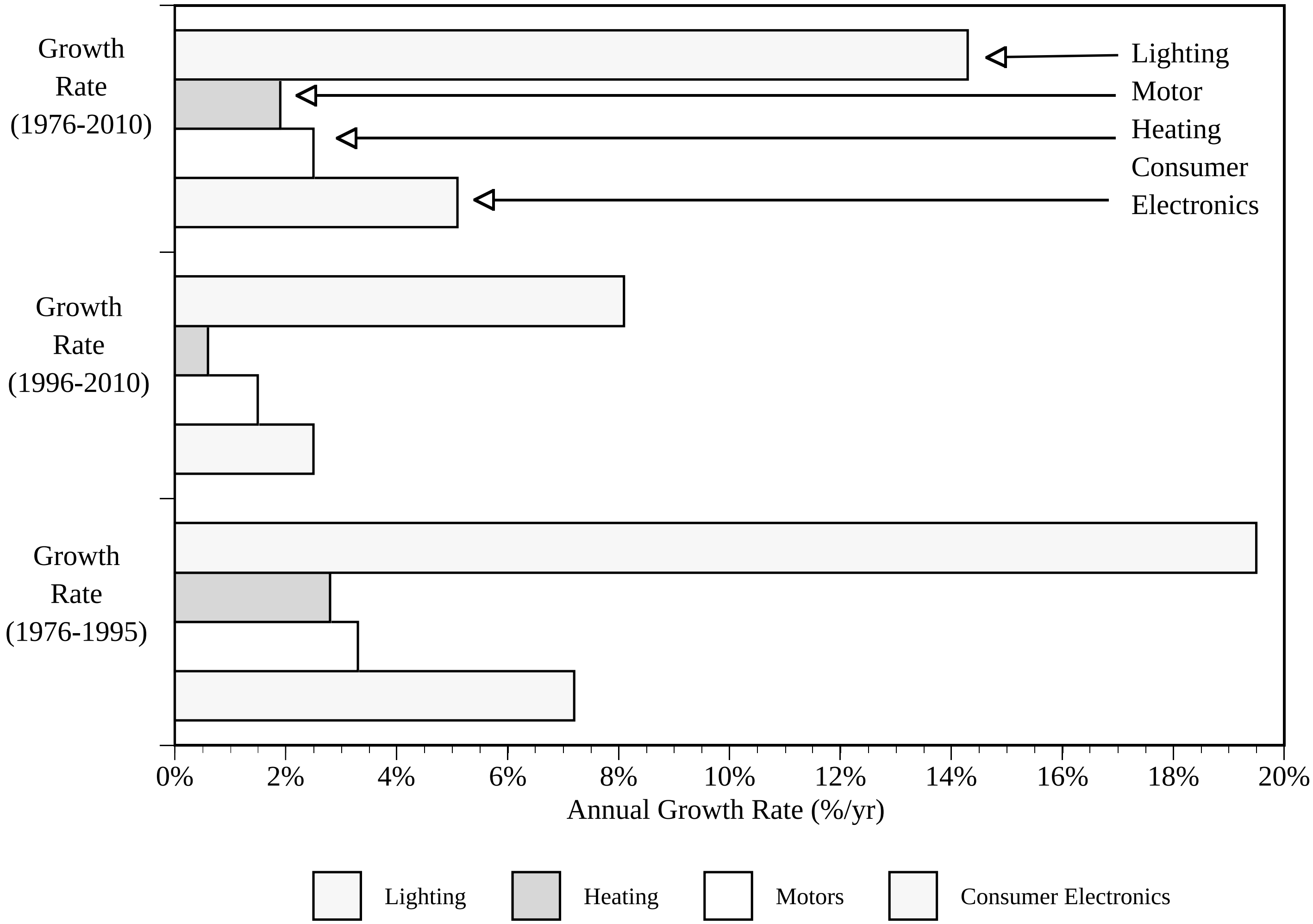
We adjusted our predicted scenario forecast to account for projected growth from new products as described in our methodology

Figure A-4: Disaggregation of Miscellaneous Energy Use by Major End Use Category



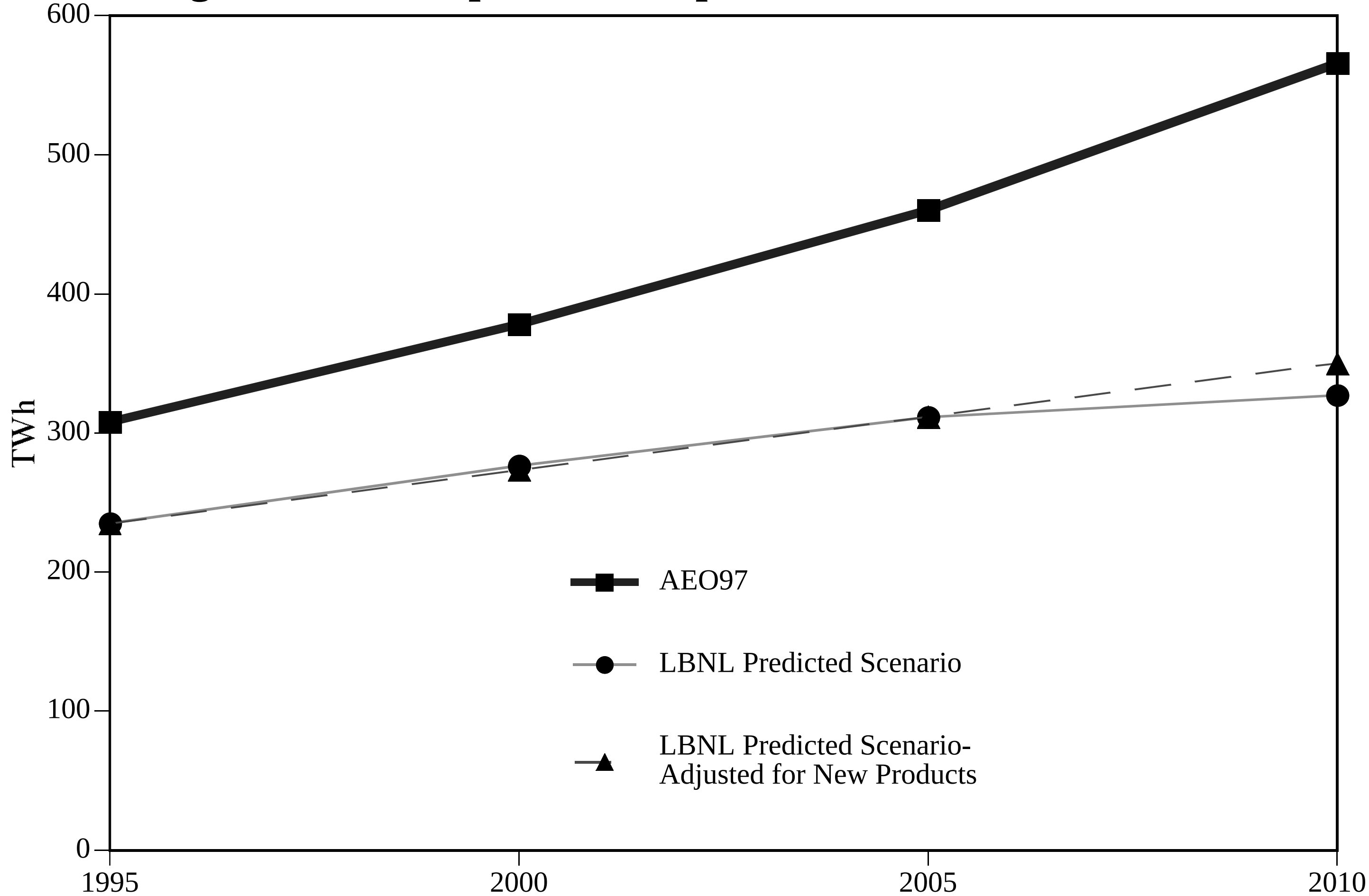
The estimated miscellaneous electricity consumption for 2010 and the projected miscellaneous growth from 1996 to 2010 does not include an adjustment for new products. This graph reflects the LBNL-predicted scenario described in the methodology.

Figure A-5: Annual Growth Rates by Major End Use Category



The end use category growth rates from 1996 to 2010 do not include an adjustment for new products. This graph reflects the LBNL-predicted scenario.

Figure A-6: Comparison Graph of AEO97 and LBNL Forecast



Our (LBNL) miscellaneous growth shown in this graph from 1996 to 2010 and our 2010 estimate of miscellaneous electricity includes expected growth from new products. This graph reflects the LBNL-Predicted Scenario Adjusted for New Products. We adjusted our predicted scenario forecasted to account for growth from new products as described in our methodology.

APPENDIX B: REPORT TABLES

This section contains the complete set of tables referred to throughout the report. To increase the readability of the report, we chose to include all tables in this appendix.

Table B-1: Residential Electricity Use (1976-2010)

End Use	TWh in 1976	% of Total	TWh in 1995	% of Total	TWh in 2010	% of Total
Miscellaneou	100	16%	235	25%	350	33%
Non-Miscellaneous Enduses	507	84%	706	75%	715	67%
Total Electricity Use	606	100%	941	100%	1065	100%

Other end uses include cooking, clothes drying, water heating, lighting, refrigeration, space conditioning

The Miscellaneous end use estimate is from our study

End use estimates for all other end uses (1976) are from Pierce (1994). Total Elec. is the sum of Miscellaneous and all Non-Misc. End uses

End use estimates for all other end uses (1995 and 2010) are from AEO97. Total Elec. is the sum of Miscellaneous and all Non-Misc. End uses

Our estimate of miscellaneous energy use in 2010 and forecasted growth from 1996 to 2010 on this table includes an adjustment for new products as described in our methodology

Table B-2: Growth in Residential Electricity and Miscellaneous Electricity (1976-2010)

End Use	Residential Electricity 1976-1995			Residential Electricity 1996-2010			Residential Electricity 1976-2010		
	Growth Rate	Absolute Growth (TWh)	Percent of Total Growth	Growth Rate	Absolute Growth (TWh)	Percent of Total Growth	Growth Rate	Absolute Growth (TWh)	Percent of Total Growth
Miscellaneous	4.6%	135.1	40%	2.7%	115.0	93%	3.8%	250.1	55%
All Non-Misc Enduses	1.8%	199.8	60%	0.1%	8.8	7%	1.0%	208.6	45%
Total Electricity Use	2.3%	334.8	100%	0.8%	123.8	100%	1.7%	458.7	100%

Other end uses include cooking, clothes drying, water heating, lighting, refrigeration, space conditioning

The Miscellaneous end use estimate is from our study

End use estimates for all other end uses(1976) are from Pierce (1994). Total Elec. is the sum of Miscellaneous and all Non-Misc. End uses

End use estimates for all other end uses(1995 and 2010) are from AEO97. Total Elec. is the sum of Miscellaneous and all Non-Misc. End uses

Our estimate for 2010 miscellaneous consumption and forecasted growth 1996-2010 on this table includes an adjustment for new products

Table B-3: Disaggregation of Energy Use 1976-2010 by Major End Use Category

	TWh					% of Total Miscellaneous Electricity				
Year	Electronics	Heating	Motor	Lighting	Total Misc. Energy Use	Electronics	Heating	Motor	Lighting	Total Miscellaneous
1976	23	33	44	0	100	23%	33%	44%	0%	100%
1980	32	40	51	0	123	26%	32%	42%	0%	100%
1985	48	48	60	1	156	31%	31%	38%	0%	100%
1990	69	53	76	1	199	34%	27%	38%	0%	100%
1995	87	55	81	12	235	37%	23%	34%	5%	100%
2000	105	57	88	26	276	38%	21%	32%	9%	100%
2005	117	59	94	40	311	38%	19%	30%	13%	100%
2010	125	61	101	40	327	38%	19%	31%	12%	100%

Our projected miscellaneous electricity estimate for 2010 and projected growth from 1996 to 2010 does not include an adjustment for expected growth from new products. The above forecast numbers reflect the LBL-predicted scenario.

Table B-4: Disaggregated growth of Miscellaneous Energy Use 1976-2010

Major End Use Category	Residential Electricity Use 1976-1995			Residential Electricity Use 1996-2010			Residential Electricity Use 1976-2010		
	Annual Growth Rate	Absolute Growth (TWh)	Percent of Total Growth	Annual Growth Rate	Absolute Growth (TWh)	Percent of Total Growth	Annual Growth Rate	Absolute Growth (TWh)	Percent of Total Growth
Consumer Electronics	7.2%	64	47%	2.5%	39	42%	5.1%	102	45%
Motors	3.3%	37	27%	1.5%	20	22%	2.5%	57	25%
Heating	2.8%	23	17%	0.6%	6	6%	1.9%	28	12%
Lighting	19.5%	12	9%	8.1%	28	30%	14.3%	40	17%
Total	4.6%	135	100%	2.2%	92	100%	3.6%	227	100%

Our projected miscellaneous electricity estimate for 2010 and projected growth from 1996 to 2010 does not include an adjustment for expected growth from new products.

The above forecast numbers reflect the LBL-predicted scenario.

Table B-5a: Composition of Heating End Use by TWh

Year	Auto Drip Coffee Maker	Crankcase Heater	Electric Blanket	Water Bed Heaters	Spas and Hot Tubs	Iron	Toaster	Hair Dryer	Other	Total Heating Energy
1976	2.0	4.4	5.2	5.9	3.4	3.8	2.8	0.0	5.1	32.5
1980	4.7	4.9	5.3	6.5	3.7	4.2	3.1	1.4	5.9	39.8
1985	6.1	5.2	5.3	9.4	4.0	4.6	3.3	2.4	7.8	48.0
1990	8.0	5.6	4.4	12.6	4.3	4.4	3.1	2.9	8.2	53.4
1995	9.4	5.9	3.5	13.2	4.5	4.5	3.3	3.0	7.9	55.1
2000	10.2	6.1	3.9	13.1	4.7	4.7	3.4	3.1	8.0	57.3
2005	10.9	6.4	4.0	12.6	4.9	4.9	3.6	3.3	8.8	59.4
2010	11.7	6.7	3.4	11.8	5.1	5.2	3.8	3.5	9.5	60.7

The above numbers for 2000, 2005, 2010 reflect the LBNL-predicted scenario.
Our estimates of projected consumption for the heating end use category from the years 2000, 2005 and 2010 are not adjusted to account for expected growth from new product types.

Table B-5b: Percent Composition of Heating End Use

Year	Auto Drip Coffee Maker	Crankcase Heater	Electric Blanket	Water Bed Heaters	Spas and Hot Tubs	Iron	Toaster	Hair Dryer	Other	Total Heating
1976	6%	13%	16%	18%	10%	12%	8%	0%	16%	100%
1980	12%	12%	13%	16%	9%	11%	8%	4%	15%	100%
1985	13%	11%	11%	20%	8%	9%	7%	5%	16%	100%
1990	15%	10%	8%	24%	8%	8%	6%	5%	15%	100%
1995	17%	11%	6%	24%	8%	8%	6%	5%	14%	100%
2000	18%	11%	7%	23%	8%	8%	6%	5%	14%	100%
2005	18%	11%	7%	21%	8%	8%	6%	6%	15%	100%
2010	19%	11%	6%	19%	8%	9%	6%	6%	16%	100%

The above numbers for 2000, 2005, 2010 reflect the LBNL-predicted scenario.
Our estimates of projected consumption for the heating end use category from the years 2000, 2005 and 2010 are not adjusted to account for expected growth from new product types.

Table B-6a: Breakdown of the Motor End Use Category by Product Type

Year	Aquaria (TWh)	Clothes washer (TWh)	Dish washer (TWh)	Evaporative Cooler (TWh)	Pool Pump (TWh)	Furnace Fan (TWh)	Well Pump (TWh)	Dehumid. (TWh)	Vacuum Cleaner (TWh)	Ceiling Fan (TWh)	Other (TWh)	Total Motors TWh
1976	2.2	4.9	4.5	2.6	1.1	14.6	4.5	2.9	2.3	0.4	3.9	43.9
1980	2.4	5.7	5.6	2.9	1.9	16.6	5.0	3.1	2.5	0.4	5.1	51.1
1985	2.6	6.5	6.3	3.1	3.0	18.2	5.4	3.2	2.7	1.8	7.0	59.6
1990	2.8	7.3	7.0	4.4	7.6	21.0	5.7	3.4	2.9	4.9	9.5	76.4
1995	4.2	7.9	7.4	3.2	6.4	21.4	4.8	4.4	3.0	7.0	11.0	80.7
2000	4.4	8.4	8.0	3.9	7.9	22.0	4.3	5.7	3.1	7.6	12.9	88.0
2005	4.6	8.9	8.6	4.1	8.7	22.4	3.8	7.7	3.3	7.7	14.6	94.4
2010	4.8	9.5	9.4	4.4	9.6	22.6	3.3	10.2	3.5	7.7	16.3	101.1

The above numbers for 2000, 2005, 2010 reflect the LBNL-predicted scenario.

Our estimates of projected consumption for the motor end use category from the years 2000, 2005 and 2010 are not adjusted to account for expected growth from new product types.

Table B-6b: Percentage Composition of Motor End Use

Year	Aquaria	Clothes washer	Dish washer	Evaporative Cooler	Pool Pump	Furnace Fan	Well Pump	Dehumid.	Vacuum Cleaner	Ceiling Fan	Other	Total Motors
1976	5%	11%	10%	6%	3%	33%	10%	7%	5%	1%	9%	100%
1980	5%	11%	11%	6%	4%	32%	10%	6%	5%	1%	10%	100%
1985	4%	11%	11%	5%	5%	31%	9%	5%	4%	3%	12%	100%
1990	4%	10%	9%	6%	10%	28%	7%	4%	4%	6%	12%	100%
1995	5%	10%	9%	4%	8%	27%	6%	5%	4%	9%	14%	100%
2000	5%	9%	9%	4%	9%	25%	5%	6%	4%	9%	15%	100%
2005	5%	9%	9%	4%	9%	24%	4%	8%	3%	8%	15%	100%
2010	5%	9%	9%	4%	9%	22%	3%	10%	3%	8%	16%	100%

The above numbers for 2000, 2005, 2010 reflect the LBNL-predicted scenario.

Our estimates of projected consumption for the motor end use category from the years 2000, 2005 and 2010 are not adjusted to account for expected growth from new product types.

Table B-7a: Composition of Electronics Category 1976

Product Name	TWh in 1976	% of Total Electronics Energy
Electric Doorbell	0.9	3.9%
Clock	1.28	5.5%
Home Radio	1.35	5.9%
Battery Charger	1.54	6.7%
Rack Audio System	1.92	8.3%
Black and White TV	2.3	10.0%
Compact Audio	3.08	13.4%
Color TV	8.1	35.1%
Total Percentage of End Use Category		84.8%

Table B-7b: Composition of Electronics Category 1995

Product Name	TWh in 1995	% of Total Electronics Energy	Total Misc. Energy	Growth 1976-1995	Percent Electronics Growth	Percent Total Misc. Energy Growth
Cordless Phone	1.5	1.7%	0.6%	1.5	2.3%	1.1%
Boom Box	1.5	1.8%	0.7%	1.5	2.4%	1.1%
Video Games	1.5	1.8%	0.7%	1.5	2.4%	1.1%
Clock	2.6	2.9%	1.1%	1.3	2.0%	0.9%
Home Radio	1.9	2.2%	0.8%	0.5	0.8%	0.4%
Answering Machine	1.9	2.2%	0.8%	1.9	3.0%	1.4%
Battery Charger	2.1	2.4%	0.9%	0.5	0.8%	0.4%
Computers	3.3	3.8%	1.4%	3.2	5.0%	2.4%
Security System	3.8	4.4%	1.6%	3.8	6.0%	2.8%
RACK Audio System	4.4	5.1%	1.9%	2.5	3.9%	1.8%
Cable Boxes	5.0	5.7%	2.1%	4.0	6.4%	3.0%
Compact Audio System	5.0	5.8%	2.1%	2.0	3.1%	1.4%
Video Cassette Recorder	6.9	8.0%	3.0%	6.9	10.9%	5.1%
Microwaves	11.3	13.0%	4.8%	11.0	17.4%	8.2%
Color TV	26.3	30.3%	11.2%	18.2	28.7%	13.5%
Summary of End Use Category	77.5	90.9%	33.0%	60.5	95%	45%

Table B-7c: Composition of Electronics Category 2010

Product Name	TWh in 2010	Percent of Total Electronics Energy Use in 2010	Percent of Total Misc. 2010	Growth 1995-2010	% of total electronics growth	% of total misc. growth
Answering Machine	1.9	1.5%	0.6%	0.0	0.0%	0.0%
Clock	2.0	1.6%	0.6%	0.3	0.6%	0.3%
Cordless Phones	2.1	1.7%	0.6%	0.6	1.5%	0.7%
Battery Charger	2.4	1.9%	0.7%	0.3	0.7%	0.3%
TV/VCR Combo	3.6	2.9%	1.1%	2.4	5.8%	2.6%
Satellite Systems	3.9	3.1%	1.2%	3.2	7.5%	3.4%
Projection TV	4.6	3.7%	1.4%	3.5	8.4%	3.8%
Computers	6.0	4.8%	1.8%	2.7	6.3%	2.9%
Cable Boxes	6.0	4.8%	1.8%	1.0	2.5%	1.1%
Video Cassette Recorder	8.3	6.6%	2.5%	1.3	3.1%	1.4%
Security Systems	9.0	7.2%	2.8%	5.2	12.4%	5.6%
Compact Audio Systems	9.8	7.8%	3.0%	4.8	11.4%	5.2%
Microwave Oven	14.9	11.9%	4.5%	3.6	8.6%	3.9%
Color TV	37.5	30.0%	11.5%	11.2	26.7%	12.1%
Summary of End Use Category	111.76	89%	32.34%	40.0	93.3%	42.5%

Estimates of 2010 consumption does not include an adjustment for new products.

Numbers above reflect the LBNL-predicted scenario.

Table B-8a: Top Ten Miscellanous Electricity Uses in 1976

Ranking	Product Name	TWh in 1976	Percent of Total Misce. Energy Use
10	Spas and Hot Tubs	3.4	3.4%
9	Iron	3.8	3.8%
8	Crankcase Heater	4.4	4.4%
7	Dishwasher Motor	4.5	4.5%
6	Well Pump	4.5	4.5%
5	Clotheswasher Motor	4.9	4.9%
4	Electric Blankets	5.2	5.2%
3	Water Bed Heaters	5.9	5.9%
2	Color Television	8.1	8.1%
1	Furnace Fan	14.6	14.6%
	Top Ten Cumulative % of total		59%

Table B-8b: Top Ten Miscellaneous Electricity Uses in 1995

Ranking	Product Name	TWh in 1995	Percent of Total Misc. Energy Use
10	Video Cassette Recorder	6.9	3.0%
9	Ceiling Fan	7.0	3.0%
8	Dishwasher Motor	7.4	3.2%
7	Clotheswasher Motor	7.9	3.3%
6	Auto Drip Coffee Maker	9.4	4.0%
5	Microwave Oven	11.3	4.8%
4	Torchiere Lamps	11.9	5.1%
3	Waterbed Heaters	13.2	5.6%
2	Furnace Fan	21.4	9.1%
1	Color Television	26.3	11.2%
	Top Ten Cumulative % of total		53%

Table B-8c: Top Ten Miscellaneous Electricity Uses in 2010, Predicted Scenario (no new product adjustment)

Ranking	Product Name	TWh in 2010	Percent of Total Misc. Energy Use
10	Clotheswasher Motor	9.5	2.7%
9	Pool Pump	9.6	2.7%
8	Compact Audio System	9.8	3.0%
7	Dehumidifier	10.2	2.9%
6	Auto Drip Coffee Maker	11.7	3.3%
5	Waterbed Heater	11.8	3.5%
4	Microwave Oven	14.9	3.5%
3	Furnace Fan	22.6	6.4%
2	Color Television	37.5	8.7%
1	Torchiere Lamp	40.1	20.0%
	Top Ten Cumulative % of total		54%

Table B-9a: Top Ten Product Energy Increase (1976-1995)

Ranking	Product Name	TWh Growth (1976-1995)	Percent of Total Misc. Growth (1976-1995)
10	Cable Box	4.0	3.0%
9	Pool Pump	5.3	4.0%
8	Ceiling Fan	6.7	5.0%
7	Furnace Fan	6.8	5.1%
6	Video Cassette Recorder	6.9	5.2%
5	Waterbed Heater	7.2	5.4%
4	Auto Drip Coffee Maker	7.4	5.6%
3	Microwave Oven	11.0	8.3%
2	Torchiere Lamp	11.9	9.0%
1	Color Television	18.2	13.7%
	Top Ten Cumulative % of total		64%

Table B-9b: Top Ten Product Type Energy Growth (1996-2010) Predicted Scenario-does not include adjustment for new products

Ranking	Product Name	TWh Growth (1995-2010)	Percent of Total Misc. Growth (1996-2010)
10	Computer	2.7	2.3%
9	Pool Pump	3.2	2.7%
8	Satellite Earth Station	3.2	2.7%
7	Projection Television	3.5	3.0%
6	Microwave Oven	3.6	3.0%
5	Compact Audio System	4.8	4.1%
4	Security System	5.2	4.4%
3	Dehumidifier	5.8	4.9%
2	Color Television	11.2	9.5%
1	Torchiere Lamp	27.5	23.3%
	Top Ten Cumulative % of total		60%

Our comparison of product type growth to total miscellaneous growth (as a %) for the period 1996 to 2010 refers to a % of total growth not adjusted for new products (the LBNL-Predicted Scenario).

Table B-10: Comparison of LBNL and RECS Miscellaneous Consumption Estimates

Data Source	1987	1990	1993	Growth Rate (1987-1993)
RECS	141.46	185.30	271.00	11.4%
LBNL	173.2	199	220.6	4.1%
% difference	18.3%	6.9%	-18.6%	-

(1) In 1987, RECS reports total energy use for water heating, space heating, air conditioning,appliances

(2) In 1990 and 1993, RECS reports total energy use for the following categories: water heating, space heating, air conditioning, refrigeration and appliances.

(3) In 1987, RECS miscellaneous category is the Appliances total minus the energy consumption of ranges freezers, refrigerators, lighting and clothes drying.

(4) In 1990 and 1993, RECS misc. category is the Appliances figure minus energy consumption of ranges, freezers, clothes dryers and lighting

Table B-11: Potential Savings from a 1-Watt Action Plan

End Use	1995 Consumption (TWh/yr)	1-Watt Consumption (TWh/yr)	Potential Savings (TWh/yr)
Microwave	2.11	0.68	1.43
Battery Charger	2.05	0.85	1.20
Men's Shaver	0.46	0.33	0.13
Women's Shaver	0.13	0.09	0.04
Electric Toothbrush	0.23	0.10	0.13
Satellite Earth Station	0.57	0.04	0.53
Home radio, small/clock	1.77	0.88	0.88
Boom Box	1.34	0.61	0.73
Answering Machine	1.92	0.58	1.34
Hand-Held Rechargeable	0.34	0.19	0.15
Cordless Phone	1.49	0.53	0.96
Cable Boxes	3.69	0.32	3.37
Video Games	1.07	0.54	0.54
Compact Audio	4.73	0.45	4.29
RACK Audio System	3.21	0.46	2.75
Garage Door Opener	0.80	0.20	0.60
Doorbell	1.20	0.60	0.60
Security System	0.88	0.07	0.81
Halogen Lights	0.17	0.17	0.00
Modem	0.20	0.15	0.06
Power Strip	0.26	0.26	0.00
Timer	0.45	0.21	0.23
TOTALS FOR TARGETED END USES (1)	29.06	8.30	20.76
TOTAL U.S. STANDBY CONSUMPTION	43.06	22.30	48% Reduction in Standby Losses

We did not include home office equipment or TVS and VCRS in the one watt analysis since they have their own energy star programs (Energy Star TV/VCR and Energy Star Office equipment)

Table B-12: Categorization of the Quality of Raw Data used in LBNL's Miscellaneous Electricity Study

Historically Well Researched End Uses	*More Detailed LBNL Research*	*Important End Uses-Rough Estimates*	*Small Housewares/ Questionable Usage*	*Potential Regional Importance-Estimates*
Television Sets	Television Set	Waterbed Heater	Iron	Sump Pumps
Microwave Ovens	Video Cassette Recorders	Furnace Fans	Toaster	Specialized heaters: Pipes, Engine, Gutters
Clotheswasher Motor	Compact Audio	Auto Drip Coffee Maker	Hair Dryer	
Dishwasher Motor	Rack Audio	Ceiling Fans	Slow Cooker	
Evap. Cooler	Aquariums	Pool Pumps	Waffle Iron	
Crankcase Heater	Cable Box	Well Pump	Hot Plate	
	Torchiere Lamp	Spa Heater/Pump	Electric Mower	
	Satellite System	Dehumidifier		
	Projection TV	Electric Blanket		
	TV/VCR Combo	Air Cleaner		
	Garage Door Opener	Humidifier		
	Boom Box	Doorbell		
	Video Game	Air Cleaner		
	Cordless Phone	Satellite System		
	Answering Machine	Battery Charger		
	Clock	Home Office		
	Home Radio			
	Vacuum			
	Security System			

APPENDICES C THROUGH K

These appendices are downloadable as Excel, Word, and Deltagraph files at the web site http://enduse.lbl.gov/Projects/ResMisc.html